

enthusiasm. Elevation perhaps comes nearest to a solution, but fails to account for world-wide cooling. The conclusion is that no single cause suffices. "Some combination of astronomic, geologic, and atmospheric conditions seems to be necessary to produce such catastrophic events in the world's history."

The difficulty of the problem is increased by the apparently haphazard way in which glaciations have developed. Time and again the author comments on the paradox of field work, especially on Permo-Carboniferous tillites, beneath an almost vertical sun in a temperature suggestive of anything but ice. On the other hand, so far as is known at present, the Antarctic continent escaped glaciation until the close of the Mesozoic, though of course the great Antarctic ice sheet may hide traces of many older glaciers. The northeast of North America, where the Quaternary ice sheets reached lower latitudes than anywhere else, has suffered glaciation over and over again. In the upper Carboniferous this region bore glaciers which indeed pale into insignificance beside the contemporaneous ice sheets of the south, but would be sufficiently remarkable in any other period. The same region was ice-covered in the Devonian, the Ordovician, at the close of the Proterozoic, in the lower Huronian (a photograph shows the remarkable feature of a Huronian tillite smoothed and striated by a Pleistocene ice sheet), and perhaps at two horizons in the Archean—seven or eight glaciations in the same or neighboring areas. Other regions which have suffered repeated glaciation are Alaska, South Africa, and southeast Australia, though South Africa was not glaciated during the Pleistocene.

It almost seems as if, given certain conditions, and especially a world-wide cooling, glaciers and even ice sheets can develop in any latitude, but have a preference for certain localities. From this point of view it may be only an accident that the two great ice sheets of the present day occur in high latitudes. Their formation is not entirely a matter of temperature, since we are faced by the idea that during most of geological time the polar regions were free of land ice even while lower latitudes were being glaciated. Apart from pole wandering, the only theory which throws any light on this anomaly is Paschinger's, not mentioned by Coleman, that glaciation depends on the relation between the zone of maximum snowfall and the snow line. It may be profitable to try to fit this theory to the facts before us.

As we go from the lowlands up the slopes of a mountain range, we find that the snowfall increases up to a certain level, above which it again decreases; this level depends mainly on the humidity and the temperature during the wettest season. Quite distinct, depending mainly on the summer temperature, is the snow line. If the snow line is above the zone of maximum snowfall, the glaciers will be small; if the snow line is the lower, the glaciers will be large, and with sufficient snowfall may descend to low levels. In the moist equatorial regions the two zones are close together, and a small depression of the snow line would produce a considerable extension of the glaciers.

It seems probable that glaciers or ice sheets must always originate on high ground, but for a glacier to develop into an ice sheet a large area of more or less level ground is required at a temperature low enough for the ice to spread out as a piedmont glacier. In high latitudes this land may be low, but in low latitudes it must be initially at a high level. Once the ice sheet has reached a certain size, however, it imports its own climate, and the initially high plateau may be depressed nearly to sea level without necessarily destroying the ice sheet. There are several reasons for this. One of the most important is that a snow surface reflects four-fifths of the solar radiation falling on it, and another is that a large ice sheet is naturally occupied by an anticyclone with outwardly directed winds. The relations between snow line and zone of maximum snowfall probably depend on conditions of storminess and vertical temperature gradient which are due to general causes; when these are favorable, glaciers will form which may develop into ice sheets in suitable localities, determined partly by configuration, which is independent of latitude, and partly by location relative to storm tracks and oceans. The latter proviso causes the repetition of glaciation in certain localities which are not necessarily the coldest parts of the globe. During the course of an ice age the most suitable location may change, which brings us back to Coleman's speculation that the Greenland ice sheet may represent the continuation of the eastward trend of glaciation in America, having commenced later than the American ice sheets and persisting after them.

The author has done good service by uniting in one volume a large mass of material which was formerly only available in scattered papers or, in the case of his own observations, had not previously been published. The volume maintains the high standard which we expect of the publishers; it is lavishly illustrated by photographs of great interest, and the only error which the reviewer has noticed is the name "Grygalski" on page 286.—C. E. P. Brooks.

THE CLIMATE OF NORTH-EAST LAND

In a paper in the *Geographical Journal* for September on the weather of North-East Land, Spitsbergen, during one month in the summer of 1924, Mr. K. S. Sandford has collected some evidence of value in relation to the problem of glacial anticyclones. In this relatively small but almost entirely ice-covered area he found no fixed anticyclone but a definite tendency toward the establishment of anticyclonic conditions with radial gravitational winds. This intermittent glacial anticyclone is blotted out by interference from outside the area but quickly reestablishes itself. Winds are markedly outflowing and lead to an augmentation of the bordering ice at the expense of the higher parts of the interior. On the other hand, interference from the outside is great and leads to melting of ice in the bordering zone and to a less extent in the interior. During the maintenance of anticyclonic conditions there is some indication of a pulsation, from calm to blizzard. Mr. Sandford believes that on New Friesland, on the mainland of Spitsbergen, there is a similar but modified system. Other parts of Spitsbergen have an insufficient ice covering for its development. Up to the present there are no winter observations available from North-East Land.—*Repr. from Nature (London), September 6, 1926.*

EXTENT OF ORCHARD HEATING IN SOUTHERN CALIFORNIA

The fruit-frost service of the Weather Bureau, in charge of Mr. Floyd D. Young, is compiling data on this subject, which when completed will form the first authoritative information with regard to it. The work is divided into eight districts, for each of which it is hoped to have complete data before the spring of 1927. In summarizing the work for the Redlands-San Bernardino district, Mr. A. W. Cook, of the Weather Bureau, writes as follows (*California Citrograph*, July, 1926):

There are 29,691 acres of citrus trees in the entire Redlands-San Bernardino fruit-frost district, of which 5,789 acres, or 19.5 per cent, are equipped with heaters. The increase in acreage protected since the spring of 1925 is 2,977, or 51.4 per cent of the total. On the basis of fifty 9-gallon oil heaters to the acre, 2,483,550 gallons, or roughly 250 carloads, of oil are required for one filling of the heaters. The Redlands section alone requires about 187 carloads of oil for one filling.

551.508 A ONE-MAN THEODOLITE

The August, 1926, issue of *Meteorologische Zeitschrift* contains a description, with illustration, of this device, which appears to be new in the field of aerology. The advantages of a one-man instrument for use on meteorological expeditions or other situation where reduction of personnel is essential are obvious.

In the new instrument the horizontal circle is retained in the form hitherto used, but the vertical circle is ingeniously incorporated within the field of vision of the telescope. The operator with his right eye not only follows the balloon with the aid of the cross hairs, but, aided by their lower vertical member as an index, he with the same eye reads the vertical angle upon an engraved glass circle. Set off at interpupillary distance to the left of the main eyepiece is the ocular of a microscope through which the observer looks, via a prism, upon the scale engraved on the horizontal circle.

Both horizontal and vertical circles are divided into whole degrees. Reading to tenths of a degree is accom-